Investigating Nao's Impact on Promoting Motor Skills in Young Children with ASD

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Abstract
This experimental study implemented a robot-based intervention in a preschool setting to explore how social robotics can promote motor skills in young children with Autism Spectrum Disorder (ASD). The study involved 20 children aged 24 to 36 months, divided into two groups of ten, each including a child with autism. The research aimed to develop specific robotic rehabilitation tools, enhance educators' communicative skills, and assess the NAO robot's effectiveness during motor activity sessions for children with autism. Results indicated that children were actively engaged with the robot, with those on the autism spectrum showing particular interest. Engagement varied, with one ASD child's curiosity driving involvement, while the other ASD child's participation required support by the educator in nurturing the child's relationship with the robot and peers.

Keywords
social robots, motor skills, autism

1. Introduction

Social robots are the subject of particular attention in intervention practices with children with Autism Spectrum Disorder (ASD) and are emerging as effective mediators in early interactions [1, 2, 3]. Innovative research on the use of social robots for ASD children is shaping new approaches in early childhood education [4]. Integrating robots into early childhood education presents an opportunity to bridge the gap between traditional and modern pedagogical practices, fostering a more inclusive environment. This approach is aligned with the framework that views inclusion as a complex concept to be addressed in the context of class-group relations rather than through a deficit paradigm, and it emphasizes equity as the right of students to universally designed learning opportunities [5, 6, 7]. An increasing number of studies have identified motor difficulties in children with ASD that are likely to affect social-communicative development negatively. An overview of the benefits of motor activity for individuals with ASD reveals physical benefits such as improvement of gross and fine motor skills, and enhancement of control and coordination [8, 9]. Additionally, there are benefits related to cognitive and emotional growth. Finally, motor activity through peer interaction can improve skills related to social interaction and communication. Most robot-based intervention studies are focused on improving emotion or social skills. While those should be extensively studied, motor skills should not be neglected since they are directly correlated with the severity of communication skills [10].

This paper examines the innovative aspect of robot-based interventions in preschool settings, namely the potential of robotic technology to transform pedagogical approaches with children with ASD through integration into early childhood inclusive education. It investigates the potential of these robots as effective tools for enhancing social interaction and learning among young children. In particular, this study explored the use of NAO, a social assistive robot, as a coach for preschool children's motor activities, including those with ASD. Positioned at the intersection of Socially Intelligent Robots and

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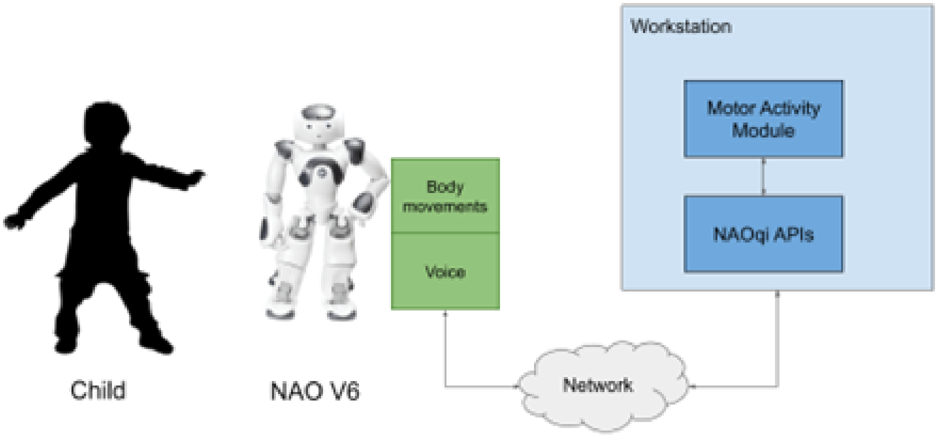

Figure 1: System Architecture. The workstation is equipped with the motor activity software module and the NAOqi APIs. The workstation is connected to the robot via a Wi-Fi router.

Assistive Robots, Socially Assistive Robots (SAR) are designed to help students reduce social impairments through social interaction [11].

2. System Architecture

The motor activity intervention for children with ASD is a targeted approach centered on body movement, delivered by a physical therapist. This system comprises various hardware and software components to create a comprehensive motor activity training platform leveraging social robotics, including:

- NAO V6 robot
- Windows 10 workstation
- Motor activity software module
- NAOqi APIs module
- Wi-Fi router

The system architecture is illustrated in Figure 1. It employs the NAO V6 humanoid social robot, paired with a workstation featuring an Intel i7 8th generation CPU and 16 GB of RAM. Developed by Aldebaran Robotics, the NAO robot stands 57 cm tall and weighs 4 kg. It boasts 25 Degrees of Freedom (DoF)—11 for the lower limbs (legs and pelvis) and 14 for the upper limbs (trunk, arms, and head). Additionally, the manufacturer offers a suite of software tools, including Choregraphe, which enables users to design and test robot behaviors on either a simulated or real robot.

2.1. Motor activity system module

The motor activity intervention exercises were developed using Choregraphe, a rapid programming tool provided by the robot's manufacturer, along with Python. The developed software was installed on the workstation and utilized NAOqi APIs to perform the five exercises of the intervention, incorporating both speech and body movements. The motor activity software module includes a set of exercises for motor intervention. In this study, motor activity exercises are defined as a collection of educational and therapeutic approaches that address the individual's body movement expression related to social, emotional, and cognitive functioning, as facilitated by a psychiatric therapist.

In our study, a subset of five motor activity exercises has been implemented on the robot, including:

1. Raise both arms up and lower them down along the sides.
2. Raise the arms up and lower them down along the sides, alternating. First the left, then the right.
3. Knee bends, up and down (like a full sack and an empty sack).

4. Open both arms and then bring them back down along the sides (like an airplane).
5. Open the arms and then bring them back down along the sides, alternating. First the left, then the right.

The system can provide a stimulus and give the child positive reinforcement. The reinforcement consists of a randomly selected word from the following: great job!, well done!, very good!, good!, great!, super!, yay!, fantastic!, you're doing great!, how nice!, perfect!, very well!

3. Procedure

The study protocol obtained approval from the Ethics Committee of the Department of Education, Psychology, and Communication Sciences at the University of Bari, confirming its compliance with ethical standards for research involving human participants. Parents provided their consent by signing an Informed Consent form, enabling their children's participation in the study responsibly. Additionally, they signed a data protection agreement to ensure the safeguarding of sensitive personal data related to the children. The study examined the relationship established during motor activities in two compared settings, specifically between a group of children and educational figures and a group of children and the NAO robot. The experiments took place in 'Le Matite Colorate Baby' nursery school in Matera, involving 20 children aged between 24 and 36 months, divided into two groups of ten subjects. Each group included a child with autism.

The research had three main objectives:

1. to gather evidence for the creation of specific devices for robot co-piloted educational mediation;
2. to develop communicative-relational skills of educators in the context of nursery school, in the presence of children with and without disabilities;
3. to evaluate the efficacy of the NAO robot as a support tool during motor activity sessions for children with autism, examining the impact of interaction with the robot on children's engagement and attention and exploring whether interaction with the NAO robot can improve the motor skills and coordination of children with autism.

The first phase saw the definition of research questions (RQ) by the research team: (RQ1) – Do children with ASD show an improvement in motor skills after participating in Nao-led activities compared to those led by the educator? (RQ2) – What differences in engagement exist between children with ASD in Nao's group and those in the control group? The video research process followed the following phases:

1. Video recording. The recording made it possible to capture the children's interactions at different moments of the motor activity and to observe situations, such as play, interaction with others, interaction with the robot and interaction with the educator. It was important to ensure that the children were comfortable and that the situations were representative of their everyday environment. The children had become familiar with the Nao robot in the pre-research phase the previous day.
2. Behavioral observation. The researchers observed the videos carefully, noting the behavior of the children in the two groups. They focused on aspects such as verbal and non-verbal communication, socialization, response to stimuli, and repetitive behaviors. To guide the analysis, the structured observation forms constructed by the research team were used, inspired by the Autism in Children Scale, the Checklist for Autism in Children.

4. Results

From the qualitative data collected, it can be deduced that: the groups of children participated actively in the sessions coordinated by the Nao robot, especially in the first session, while they responded better with the mediation of the educator in the second session. Regarding analyses of the behavior of children with autism, the child in the first group (with Level II autism, impairment in the area of communication and social interaction and limited interests and repetitive behaviors) showed signs of fatigue and distraction during the activity, receiving support from the educator several times. The child in the second group (child 2) showed more autonomous involvement and curiosity throughout the activities. This may be due to the fact that, even if their level is the same, they are different in the spectrum, and this outlines the need for personalized robot intervention. Moreover, the relationship between children with and without autism and educators is of fundamental importance in the development and learning of children. Educators provide emotional, cognitive and social support that helps children grow, learn and develop in a healthy and balanced way. The child-educator relationship was characterized by several key elements as empathy, trust, mutual understanding and the ability to adapt to individual needs. Indeed, the educators have interpreted and responded to the nuances of emotions, non-verbal signals and children's needs, creating a safe and stimulating educational environment. On the other hand, the relationship between children and robots is still in development and cannot completely replace the relationship with educators. Robots can offer complementary educational support, but, at present, they cannot provide the same range of interactions and personalized responses that educators can offer. However, robots can play a significant role in supporting education, especially when used as assistive tools or to support the learning of certain skills. Robots can provide immediate feedback, personalized exercises, and represent interactive characters that engage and motivate children in educational activities.

5. Conclusion

It is important to consider that the child-educator relationship and the child-robot relationship can coexist and complement each other. Educators can use robots as additional resources to enrich the educational experience, facilitate collaborative learning and encourage creativity and innovation. The relationship between children with autism and robots can offer several significant benefits. Here are some of the main advantages that emerged:

1. Communication and social interaction: robots can be programmed to interact with children with autism in specific and predictable ways. This can facilitate communication and social interaction, providing a comfortable and non-threatening environment for children. Robots can encourage children to express their emotions, develop conversational skills and improve social skills.
2. Structured learning: children with autism tend to benefit from a structured and predictable environment. Robots can provide structured learning activities and programs, adapted to the individual needs of children. This can help children develop cognitive, language and motor skills through interaction with the robot.
3. Reducing anxiety and stress: for many children with moderate or severe autism, social interactions can be a source of anxiety and stress. Robots can provide a reassuring and less intimidating alternative to interactions with humans. This can help children feel more comfortable and reduce anxiety and stress during learning and socializing activities.
4. Neutral feedback: robots can provide neutral and consistent feedback to children with autism. This can be especially helpful for children who may be sensitive or react negatively to human feedback. The robot's neutral feedback can be used to encourage and reinforce positive behaviors, providing a non-judgmental learning environment.
5. Motivation and involvement: robots can be designed to be engaging and interesting for children with autism. The interactive and playful features of robots can stimulate children's motivation and attention, encouraging interest in and commitment to learning activities.

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